

The Better You Are the Stronger It Makes You

Evidence on the Asymmetric Impact of Liberalization

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Abstract

This paper studies how liberalization affects productivity growth using micro-level plant data. While previous studies have already shown the existence of a positive relationship between competition and economic performance, the novelty of this paper is that it analyzes not only the average impact of liberalization, but also goes “beyond the average” and shows how the liberalization can affect dissimilar plants in a different way. The author first develops a model which predicts that, while the impact of liberalization on productivity growth is positive “on average”, more advanced firms tend to benefit more. In fact, liberalization generates two competing effects: on one side it spurs more innovative efforts because of the increased entry threat by foreign competitors, on the other side, enhanced competition curtails expected profits and reduces the funds available to finance innovative activities. The pro-competitive effect is weaker for less advanced firms as for them it is

harder to catch-up with the “technology frontier”. These predictions are then tested focusing on Mexican plants during the NAFTA liberalization. The results show that a 1 percent reduction in tariffs spurred productivity growth between 4 and 8 percent on average. However, for backward firms this effect is much weaker if not close to zero, otherwise for more advanced ones this effect is stronger with productivity growing between 11 and 13 percent. Consistent with the theoretical model the results are stronger in those sectors where the scope for innovative activities is more pronounced. These results are particularly important for policy makers because they suggest that while increasing competition may be good in spurring average productivity, it is also true that this effect does not hold for all type of firms, in particular more backward firms may need some complementary support policy to upgrade their capacities and keep up with the more competitive environment.

This paper—a product of the Trade Team, Development Research Group—is part of a larger effort in the department to understand the links between competition and innovation. Policy Research Working Papers are also posted on the Web at <http://econ.worldbank.org>. The author may be contacted at Liacovone@worldbank.org.

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The Better You Are the Stronger It Makes You: Evidence on the Asymmetric Impact of Liberalization*

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1 Introduction

“Do countries with lower barriers to international trade experience faster economic progress? Few questions have been more vigorously debated in the history of economic thought, and none is more central to the vast literature on trade and development.” (Rodriguez and Rodrik 1999)

The relationship between liberalization and economic performance has been strongly debated since Adam Smith and it is still today at the center of disputes. Even more than academic economists, policy makers consider the subject central to their concerns. In particular developing countries, that during the 1990s have undergone profound liberalizations¹ with the objective of improving their economic performance and accelerating their growth rates, have recently started to put these policies under discussions because of mixed results.² In this study we will try to explain why liberalization can result in outcomes that are different depending on the context and, more in particular, are uneven for heterogenous firms.

In this paper we develop a model that shows how the impact of liberalization can be asymmetric for different types of firms and test its main predictions focusing the liberalization that Mexico underwent during NAFTA. This provides an excellent opportunity to study a deep process of liberalization and integration with the global economy that increased the pressures from import competition and entry threat of foreign competitors. We will analyze it and show that, consistent with our theoretical model, the impact of NAFTA was highly asymmetric on different types of firms and, while productivity growth “on average” is larger for those firms in sectors where tariffs dropped more, at the same time, this effect is weaker for plants more distant from the production technology frontier.

A number of previous studies using firm-level³ data have already shown that an increase in import competition tends to have a positive impact on economic performance (Tybout and Westbrook 1995, López-Córdova 2003, Pavcnik 2002, De Hoyos and Iacovone 2006, Nickell 1996, Fernandes 2007). However, these studies normally focused on the “average” impact of liberalization and implicitly as-

¹As discussed in a recent World Bank report over the last few decades almost all developing countries have liberalized their trade regimes (Bank 2006)

²“In many developing countries, there has already been a de-industrialisation process in which lowering of tariffs has led to imports displacing local industries” (Martin Khor 1999, Director of Third World Network)

“Some trade critics are bothered by the disappointing performance of Latin America since it slashed tariffs in the 1980s and 1990s while more protectionist China and Southeast Asia sped ahead” (“Pains from free trade spurs second thoughts”, Wall Street Journal, 30 March 1997).

³In the paper we refer interchangeably to “firm” and “plant”, however it is important to emphasize that in our empirical analysis the unit of observation will be the plant consistently with the unit of observation of our data.

sume that the effect of liberalization is homogeneous for all firms.⁴ Differently, some recent work from Aghion, Blundell, Griffith, Howitt, and Prantl (2004) shows that the effect of competition is non-linear and heterogenous depending on the productivity level of the firm. Only “*good firms*” (e.g. close to the productive frontier) are positively affected by competition as their innovative effort is enhanced in response to the increased entry threat of foreign competitors. Vice-versa “*bad firms*” (e.g. far from the productive frontier) are negatively affected because the intensified entry threat only reduces their expected profits as their efficiency is too low to allow them to compete successfully with foreign entrants (Aghion, Burgess, Redding, and Zilibotti 2004).

In this paper we contribute to the existing literature in two ways. On the theoretical front we develop a neo-Schumpeterian model that extends previous work by Aghion, Blundell, Griffith, Howitt, and Prantl (2004) and still reaches consistent results with their model at industry-level, while generating novel results at the firm-level. These results are more in line with much of the firm-level studies pointing toward a positive impact trade liberalization on firm performance “on average”. Consequently we bring such a model to the data and test it by using plant-level data from a developing country. Our approach, differently from much of the previous literature that analyzed the effect of liberalization in a cross-country setting focusing mostly on outcomes (e.g. relationship between growth and openness), is much more micro and concentrates on a specific mechanism through which liberalization may influence firms’ responses (see literature review by Hallak and Levinsohn (2004)).

The paper is divided into five sections. In the next section we discuss the existing literature related to our study. In the third one we present a set of stylized facts and sketch the theoretical model, which generates two main predictions tested in the subsequent econometric analysis presented in section four. The last section concludes and highlights some avenues for further research.

2 Existing Literature

This paper is related to various strands of the literature, in particular the recent works of Aghion and Bessonova (2006) and Aghion, Burgess, Redding, and Zilibotti (2004) arguing that liberalization boosts innovative efforts, but only for those firms that are more productive while it weakens the incentive to innovate for less productive ones. These models are characterized by three main elements. First, innovation is the main driver of firm-level growth. Second, a firm innovates as long as its post-innovation profits are larger than pre-innovation ones. Third, the effect of a successful innovation is limited and a firm can only advance “*one step a time*” over the “productivity ladder”. This implies

⁴Schor (2004) study on Brazil and more recently Lileeva and Trefler (2007) using Canadian plants data are two notable exceptions.

that if a firm is close to the productive frontier by innovating it will prevent entry of potential foreign competitors.⁵ However, if a firm is far from the productive frontier then it does not have any chance of preventing a foreign competitor from entering and taking over its market. In such a model, tariffs reduction increases the entry threat and boosts the incentives of “advanced” firms to innovate in order to preempt the potential foreign entry. For these firms, the increased competition reduces more the pre-innovation profits than post-innovation profits because if the firm does not innovate it risks losing all its market due to the entry of the foreign competitor. At the same time the consequences for less productive firms are very different because the increased entry threat reduces the post-innovation profits more than the pre-innovation ones. In fact, the “laggard incumbents” (i.e. less productive) cannot prevent the entry of foreign competitors, even when able of innovating successfully because they are too far from the productive frontier.

Also, related to this paper is the large set of studies arguing that increased competition puts pressures on “slacking managers” and pushes them to reduce the X-inefficiency (Martin 1978, Martin and Page 1983, Leibenstein 1978). However, all these studies rely on a set of restrictive assumptions and normally assume that firms are homogeneous (Rodrik 1988).

Our work is clearly linked to previous empirical studies analysing the effect of competition on innovative activities and productivity growth even if the earlier studies could only rely on industry-level data (Gerosky 1990, Haskel 1992). Even more relevant to our study are the more recent analysis using firm-level data to evaluate the impact of competition on productivity and innovation (Nickell 1996, Disney, Haskel, and Heden 2003) as well as the studies evaluating directly the impact of trade liberalization on firm-level productivity (Tybout and Westbrook 1995, Pavcnik 2002, Fernandes 2007, De Hoyos and Iacovone 2006). However, as previously mentioned, these studies focus on the average effect of liberalization and do not account for the possibility that this effect could be different across heterogeneous firms. Two notable exceptions, that we are aware of, are Schor (2004) Lileeva and Trefler (2007) that allow for the impact of liberalization to be heterogeneous across different firms but use a different methodology from the one adopted in this paper.

In the same spirit of our study, a couple of recent papers analysed the impact of FDI spillovers and

⁵Foreign competitors are assumed to be at the frontier, therefore when they enter the domestic market they force domestic firms that are not at the frontier to exit because they can produce the same good more efficiently. Another possibility is that even if foreign firms don’t produce exactly the same good their entry on the domestic market can increase the elasticity of substitution of domestic consumers and push mark-ups of domestic firms down, in this case only more productive firms would be able to survive in the more competitive environment. The bottom line is that increased competition will affect the elasticity of demand and therefore the markup of domestic firms. In fact, enhanced import competition can also shift the demand for domestic varieties in and, even with fixed markups, domestic firms are worse off as they have to spread their fixed costs over a reduced output.

foreign ownership exploring the possibility of heterogenous impacts on firms with different productivity levels (Griffith, Redding, and Simpson 2003, Sabirianova, Terrell, and Svejnar 2005).

This paper is very much part of the growing literature on heterogeneous firms showing how firm heterogeneity interacts with external policy changes generating dynamics that fits much better the empirical evidence (Jovanovic 1982, Hopenhayn 1992, Melitz and Ottaviano 2003, Melitz 2003, Helpman, Melitz, and Yeaple 2004, Bernard, Redding, and Schott 2004, Yeaple 2005). In particular these studies show how the impact of liberalization and globalization is highly asymmetrical depending on the initial productivity of the firms, with more productive firms benefitting disproportionately more from globalization than less productive ones.

3 Trade Liberalization and Productivity

3.1 The Facts

First of all, before starting to discuss more in details the NAFTA reform and its impact we think it is crucial to draw the attention on the importance of micro-level heterogeneity. With this objective we compare in Fig. 1 the log ratio of the median⁶ sectoral labor productivity to the median labor productivity of the entire manufacturing sector (panel a) with the log ratio of the plant-level labor productivity to the median productivity of its sector (panel b).⁷ Comparing these two graphs we notice that the productivity spread between different sectors is not much larger than the productivity spread within sector. This confirms the existence of a substantial degree of micro-level heterogeneity within-sector and reinforces the importance of focusing on the potential heterogeneity of the impact of the trade reforms. We are certainly not the first to discover and emphasize the importance of plant-level heterogeneity, in fact in an important review of various plant-level studies Tybout (2000) noticed how one of the distinctive features of LDCs manufacturing sector is its dualism where “large numbers of microenterprises and a handful of modern, large-scale factories produce similar products side by side”. Further, productivity dispersion is not necessarily a feature of developing countries as remarked by Tybout (2000) and Bartelsman and Doms (2000). In fact, previous empirical studies for both developing and developed countries have confirmed the persistence of a high degree of heterogeneity even after a profound liberalization process. For example, in the case of Chile during the

⁶Using the mean instead than the the median lead to results substantially identical, however we prefer to show the median because we think this is a better descriptive statistic in a situation where the distribution is particularly skewed.

⁷Sector is defined at the most disaggregated level allowed by the Mexican industrial classification system (CMAP), i.e. 6 digits.

1980s and 1990s Crespi (2005) found that firms in the top decile have labour productivities that are 256 percent larger than those in the bottom decile, while Disney, Haskel, and Heden (2003) found a difference of “only” 155 percent.⁸

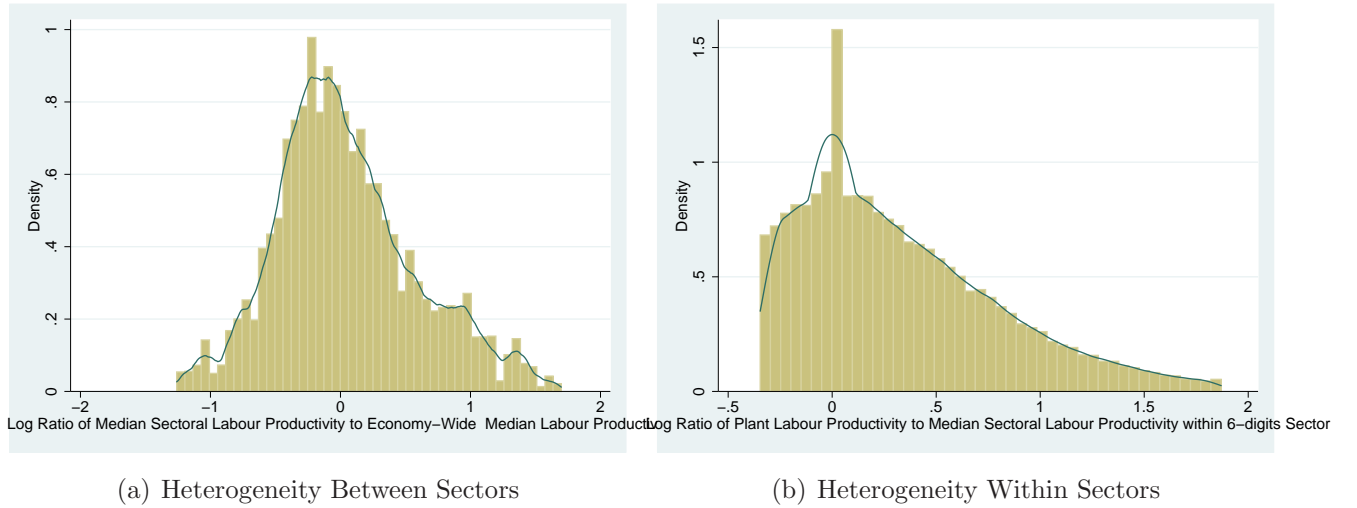


Figure 1: Firms Heterogeneity (Source: INEGI, Aguascalientes)

Having shown some evidence on the importance of plant-level heterogeneity, we now want to show how after the implementation of NAFTA we observe a remarkable increase in industrial inequality with good firms getting better, and larger firms getting larger.

If we analyze the evolution of productivity⁹ during the period 1993-2002 we observe two fundamental trends: a shift in the mean productivity, as Mexican firms became on average more productive, and an increase in the spread of the productivity distribution.¹⁰ These trends emerge from figure 3 where

⁸The explanations for this heterogeneity can be divided into two mayor groups. Traditionally, researchers have pointed towards supply-side explanations such as technological efforts and uncertainty surrounding technological investments (Nelson 1981), management or ownership, human capital as well as complementary investments in organizational capital, and matching between skills and organisation (Bartelsman and Doms 2000). For example the findings that productivity ranking tends to be relatively stable seems to imply that managerial skills, or some other persistent productivity shocks, are important determinants of this heterogeneity (Baily, Hulten, and Campbell 1992). Another potential explanation, hard to pinpoint convincingly, points toward the existence of external economies as documented by Krizan’s (1995) findings that there is a positive correlation between plant level productivity and regional economic activities in various developing countries. More recently, Syverson (2004) suggested that also demand side reasons can be important to explain this heterogeneity, in particular product heterogeneity and their substitutability plays an important role. Finally, external to the firm, regulations and exposure to international competition can be important in explaining part of the observed heterogeneity (Tybout 2001, Tybout 2000, Bartelsman and Doms 2000).

⁹We use as productivity index the value added labour productivity.

¹⁰We also test the hypothesis that the productivity spread got larger more formally by regressing the coefficient of variation, calculated within each narrowly defined sector at six digits, on a linear trend. We find that the coefficient on the linear trend estimated with a FE model is positive and statistically significant confirming that dispersion of

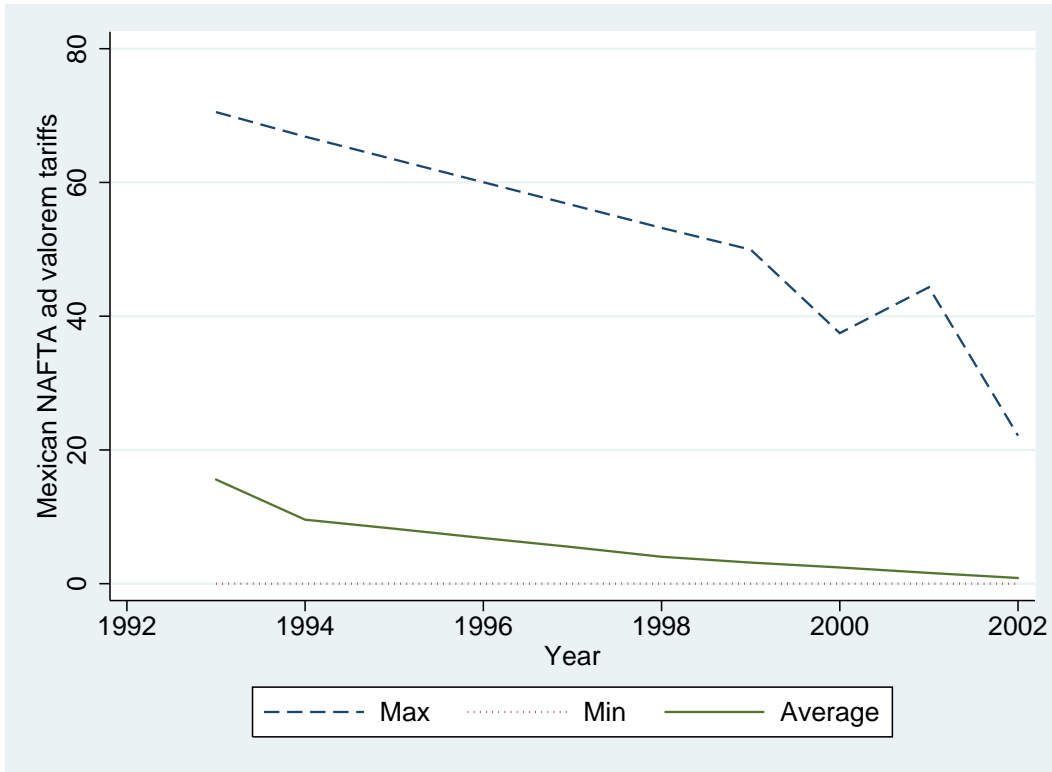


Figure 2: Import Tariffs Drop under NAFTA (Source: Secretaria de Economia, Mexico)

we plot present the distribution of the gap between each individual firm-level productivity and the “productive frontier”, in years 1993 (dashed line), 1998 (dotted line) and 2002 (continuous line). The gap is defined as the log of the ratio between the average productivity of the top five firms in the sector and the individual firm labour productivity.¹¹ A larger ratio identifies firms more distant from the productive frontier. In figure 3 we observe the distribution moving rightward, indicating that the gap between the average, or the median, Mexican firm and the “productive frontier” is expanding. At the same time, we see that the right tail of the distribution is also getting fatter implying an increase in the density of firms with larger gaps.

This expansion in productivity inequality is even more interesting if we consider that during this period we observe the exit of a significant number of less productive firms. In fact, fig. 4 depicts the number of number of exiting plants in Panel (a), and shows in Panel (b) that the average productivity of exiting plants (dashed line) is always substantially smaller than the average productivity of surviving ones (continuous line). In a nutshell, after NAFTA was implemented besides a substantial exit of less productive plants, which should compress the productivity distribution by trimming its left tail, we observe an increase in productivity inequality among surviving Mexican firms.

productivity among firms even within narrowly defined sectors got larger during the period under analysis.

¹¹To avoid the risk of having an excessively narrow definition of sector we define the “productive frontier” at 4 digits.

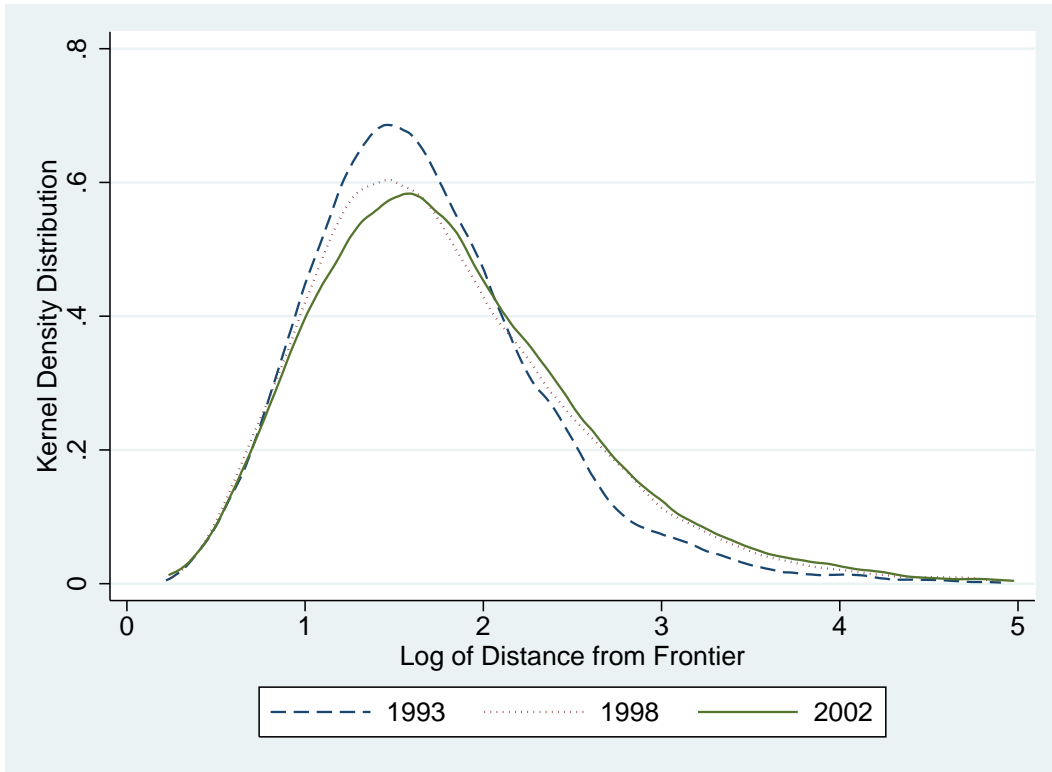
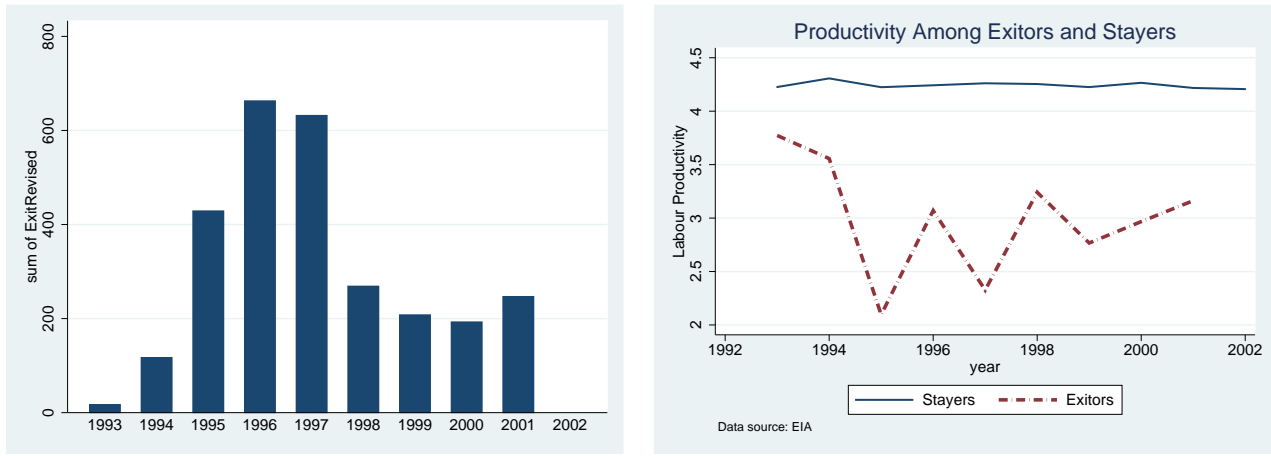


Figure 3: Distance From Frontier (Source: INEGI, Aguascalientes)

To conclude this section we want to discuss the importance of the liberalization process under NAFTA. During the 1990s Mexico underwent a process of deep integration with its the North-American economies. This process marked the completion of a liberalization already started during the second part of the 1980s. However, it is important to notice that, differently from the unilateral liberalization of the 1980s, the liberalization under NAFTA locked in Mexican policy makers much more than the previous reforms because of the credibility imposed by an agreement with a powerful counterpart. Therefore, when considering the scope of the liberalization under NAFTA we need to take into account also the importance of this credibility effect (Tomz 1997, Tornell and Esquivel 1995). In this perspective, NAFTA implied a deeper liberalisation than the drop in the average tariffs would suggest. would appear from just looking at the drop in the average tariff. Furthermore in figure 2 we show that the NAFTA tariffs¹² drop was not negligible, while the average tariff went down from about 16% in 1993 to less than 5% in 2002, the tariff peak was reduced from about 70% in 1993 to about 20% in 2002.

¹²Tariff rates for commodities produced in US or Canada.



(a) Number of Exiting firms

(b) Average Productivity of Exiters vs Stayers

Figure 4: Firms Demography (Source: INEGI, Aguascalientes)

3.2 The Model

In order to explain the facts presented in the previous section, in particular the increase in the industrial inequality in a period of profound liberalization we develop a model with heterogeneous firms based on neo-Schumpeterian growth models. The key intuition here is that liberalization can generate at the same time contrasting effects on the incentives to innovate. On one side, higher competition can hamper the innovative efforts of incumbent firms by reducing their expected profits.¹³ At the same time, the liberalization may lead incumbent to increase their innovative efforts in order to “escape competition”. The synthesis provided by the neo-Schumpeterian growth models consists exactly in allowing these two mechanisms to coexist and interplay, and in this manner it provides us with the theoretical basis that could explain the stylised facts presented in Section 3.1.

Now we will briefly sketch our model, which builds on the work of Aghion, Burgess, Redding, and Zilibotti (2004) and Aghion, Bloom, Blundell, Griffith, and Howitt (2002). The principal innovation of our model is that we relax the assumption that the impact of increased competition on backward firms is invariably negative. Instead, we will allow also backward firms to be able to catch-up with the productive frontier, even if this will be less likely because of their initially disadvantaged condition. We characterize this model by discussing separately in each one of the following subsection (1) domestic production, (2) innovation decision, (3) foreign competition, (4) equilibrium innovation.

¹³This effect is referred to as “*Schumpeterian effect*” by Aghion, Bloom, Blundell, Griffith, and Howitt (2002)

3.2.1 Domestic production

In the economy we have a final good y that is produced using a continuum of intermediate goods $v \in [1, 0]$. The production is described by equation 1 where $x_t(v)$ is the quantity used of the intermediate input v and $A_t(v)$ measures its productivity at time t , finally α is a parameter varying between 0 and 1. This final good can be consumed, used to produce intermediate inputs or invested in innovation.

$$y_t = \frac{1}{\alpha} \int_0^1 A_t^{1-\alpha}(v) x_t^\alpha(v) dv \quad (1)$$

Each intermediate good is produced by a monopolist¹⁴ at a constant marginal cost equal to one unit of the final good. The monopolist maximizes its profits but its monopoly power is restricted by the existence of a set of “fringe firms” that do not operate in equilibrium but could produce the same input using χ unit of output. Basically χ is a parameter capturing the competition intensity and is larger than 1. Therefore the maximum price that the monopolist can charge for the intermediate good v is $p_t(v)$ and can be expressed in terms of the output that is the numeraire

$$p_t(v) = \chi \quad (2)$$

Because the final-good producing sector is perfectly competitive the price of the intermediate good v must equal to its marginal product

$$MP_t(v) = \frac{dy_t}{dx_t(v)} = \alpha (x_t(v)/A_t(v))^{\alpha-1} \quad (3)$$

therefore from 3 and 2 we obtain that

$$x_t(v) = (\chi/\alpha)^{\frac{1}{\alpha-1}} A_t(v) \quad (4)$$

The model can be then solved and Aghion and Griffith (2005) show that the profit function¹⁵ is inversely correlated with the strenght of th competition, proxied by χ , and positively correlated with the productivity of the firm producing the intermediate input v as described in equation 5:

$$\pi_t(v) = A_t(v) \delta(\chi) \quad (5)$$

where

$$\delta(\chi) = (\chi - 1) \frac{\chi^{\frac{1}{\alpha-1}}}{\alpha} \quad (6)$$

3.2.2 Innovation decision

In each period the technological frontier evolves exogenously at a rate g as described by equation 7

¹⁴This assumption can be changed and have two producers competing for example under Bertrand competition.

¹⁵To confirm this it is sufficient to substitute 4 and 4 in the equilibrium profit that is $\pi_t(v) = (p_t - 1) x_t(v)$

$$\bar{A}_t = \bar{A}_{t-1} (1 + g) \quad (7)$$

and there can be two types of firms as explained by the following equation

$$\text{Firm type} = \begin{cases} \text{Advanced or type 1} & \text{if at the end of } t-1 \quad A_{t-1} = \bar{A}_{t-1} \\ \text{Backward or type 2} & \text{if at the end of } t-1 \quad A_{t-1} = \bar{A}_{t-2} \end{cases}$$

In order to characterise the innovation decision we will assume that the advanced firm will successfully innovate, and catch up, with probability z , where z is exactly measuring its research effort. Analogously, also the backward firm is able to innovate, however, because of its relative position with respect to the technological frontier, when it does innovate and move “one step forward” with probability z this is not enough to catch up with the frontier.¹⁶ In fact, in order to catch up the backward firm needs to move “two steps ahead” over the technology ladder and to do so it needs to make an extra innovation effort. This extra effort will be succesfull only with probability s , this being smaller than z .

In the original version of the model presented by Aghion and Griffith (2005) the backward firm does not have any chance of catching up, that is innovating and moving “two steps ahead”, so the introduction of this extra effort and the fact that the backward firm is able to catch up with probability s is the principal innovation of our model. However, in order to make this more realistic we will impose that this probability s is lower than z , or in other words it is more likely that a firm is successful in moving “one step” ahead rather than “two steps”. To simplify we can also assume that

$$s = \theta z$$

where θ is a parameter that we assume smaller than one but not smaller than g . Basically we want to allow the backward firm to be able to catch up with the technological frontier.

$$g \leq \theta \leq 1 \quad (8)$$

Following Aghion, Burgess, Redding, and Zilibotti (2004) we assume that the cost of innovating is quadratic in the research effort and linear in the current technological level as in equation 9. However, for backward firms we need to take into account also the cost of the extra-effort. So the innovation cost function is c_{1t} for the advanced firm and c_{2t} for the backward

$$\text{Innovation Cost} = \begin{cases} c_{1t} = \frac{1}{2}z^2 A_{t-1}(v) \\ c_{2t} = \frac{1}{2}z^2 A_{t-2}(v) + \frac{1}{2}s^2 A_{t-2}(v) \end{cases} \quad (9)$$

¹⁶We need to remember that the backward firm has at the end of $t-1$ a productivity equal to \bar{A}_{t-2}

At the end of every period, all firms that remain backward will then be upgraded automatically, assuming there are spillovers from mature technology, and move up one step in the technology ladder.¹⁷ Also, at any moment t there is an exogenous probability h that any firm may exit and be replaced by a new advanced firm at time $t + 1$.

3.2.3 Foreign competition

In every period foreign competitors can enter the domestic market, and their decision is done after having observed the outcome of the innovation effort of the domestic firms. A foreign company needs to incur in a sunk cost equal to ξ to enter the domestic market. Once it has paid this, the firm will be able to successfully penetrate the domestic market with probability μ .¹⁸ Because, foreign firms are assumed to be at the technological frontier, if it does enter and faces a backward domestic firm, then it gains the entire market if, otherwise, it faces a domestic firm at the frontier then they engage in Bertrand competition and both firms will see their profits go to zero. Consequently the entry threat simplifies into the following condition

$$\text{Entry Threat}_t = \begin{cases} 0 & \text{if domestic firm is at frontier in } t-1 \text{ and innovates successfully in } t \\ & \text{or is backward in } t-1 \text{ but able to reach the frontier in } t \\ \mu & \text{otherwise} \end{cases}$$

3.2.4 Equilibrium innovation

The solution of the expected profit maximization problem for the backward firm is obtained by solving equation 10

$$\max_z E[\pi_{2t}] = \delta(\chi) \left[z(1 - \mu)\bar{A}_{t-1} + (1 - z)(1 - \mu)\bar{A}_{t-2} + s\bar{A}_t + (1 - s)\bar{A}_{t-2}(1 - \mu) \right] - \frac{1}{2}(z^2 + s^2)\bar{A}_{t-2} \quad (10)$$

because when, with probability z , this firm is successful in moving one step ahead and obtain a productivity \bar{A}_{t-1} , it will retain its domestic market only if the foreign firm does not enter.¹⁹ Similarly, when it is unsuccessful at innovating with probability $1 - z$ and maintains productivity \bar{A}_{t-2} , it will retain its market only if the foreign firm does not enter, with probability $1 - \mu$. The backward firm also engages in an extra-effort to catch-up with productive frontier and, if successful, with probability s , obtains a productivity equal to \bar{A}_t and retains the market. While if unsuccessful, with probability $1 - s$, it maintains productivity \bar{A}_{t-2} and retains its domestic market as long as the foreign firm is unable to enter with probability $1 - \mu$. Solving this maximization problem we obtain the optimal

¹⁷This allows us to have only two types of firms to deal with.

¹⁸ μ is a proxy capturing how difficult is to enter the domestic market, i.e. tariffs and regulations directly affect μ .

¹⁹The probability that the foreign firm is unsuccessful in entering the market is exactly $1 - \mu$.

innovative effort z_{2t}^* of the backward firm 11

$$z_{2t}^* = \frac{\delta}{1 + \theta^2} [g(1 + 2\theta + \theta g) + \mu(\theta - g)] \quad (11)$$

At the same time the advanced firm chooses its optimal innovation effort z_{1t}^* maximising its expected profits π_{1t} as in equation 12

$$\max_z E[\pi_{1t}] = \delta(\chi) [z\bar{A}_t + (1 - z)(1 - \mu)\bar{A}_{t-1}] - \frac{1}{2}z_t^2\bar{A}_{t-1} \quad (12)$$

because it retains the market when it successfully innovates, with probability z , and obtains a productivity \bar{A}_t , in which case the foreign firm stays out of the market. The advanced firm also keeps its market if unsuccessful at innovating, with probability $1 - z$, and a resulting productivity of \bar{A}_{t-1} as long as, with probability $1 - \mu$, the foreign firm is unable to enter. Therefore the optimal innovation effort of this firm is equal to

$$z_{1t}^* = \delta(g + \mu) \quad (13)$$

After having derived the optimal innovative effort for both firms, we can now determine what is the effect of a reduction in import barriers which increases entry threat. In particular we derive two predictions from equations 11 and 13.

$$\frac{dz_{2t}^*}{d\mu} = \frac{\delta}{1 + \theta^2} (\theta - g) \quad (14)$$

$$\frac{dz_{1t}^*}{d\mu} = \delta \quad (15)$$

Prediction 1: Liberalization by increasing entry threat (μ) increases the optimal innovative effort of all types of firms

Prediction 2: Liberalization increases the optimal innovative effort of advanced firms more than that of backward firms

The first prediction derives immediately from the fact that both δ and $\frac{(\theta - g)}{1 + \theta^2}$ are positive. The second prediction is a consequence of $\frac{(\theta - g)}{1 + \theta^2}$ being smaller than one.

The predictions of our model are consistent with those of Aghion, Burgess, Redding, and Zilibotti (2004) at industrial level because an increase in the foreign competition (increase in μ) expands industrial inequality as advanced firms react to it with a larger innovative effort than backward ones. However, when we analyze the model prediction at firm level, our model implies that the effect of liberalization is, on average, positive for both advanced and backward firms, while in Aghion, Burgess, Redding, and Zilibotti (2004) the impact on backward firms innovative effort is always negative because the Schumpeterian effect dominates.

The predictions of our model are consistent with the basic intuition from the previous literature on X-efficiency suggesting that increased competition is expected to spur efforts (Leibenstein 1978),

as well as various empirical studies analyzing the impact of trade reforms on productivity. These studies normally found that the “average” effect of increased competition is positive (Tybout and Westbrook 1995, Fernandes 2007, De Hoyos and Iacovone 2006, Nickell 1996). In other words, our model extends Aghion, Burgess, Redding, and Zilibotti (2004) and Aghion and Griffith (2005) by making their predictions more in line with previous empirical studies but maintains intact its central feature, which is that liberalization has an unequal effect and advanced firms benefit more from it.

4 Econometric Analysis

The econometric analysis is split into two sub-sections. In the first we briefly describe the data while in the second section we analyzed the relationship between liberalisation and productivity. In particular we will build an empirical model in order to explore the potential firm heterogeneity and allow the impact of liberalization to be dissimilar for different types of firms.²⁰

4.1 Data

The data used in this analysis are provided by INEGI and cover the entire period of NAFTA reforms, 1993-2002. The data are collected at plant level, and individual establishments are identified through a unique key that allow us to build a panel.²¹ After having cleaned the dataset the number of establishments varies between 6,500 and about 5,000 because of attrition.²² The sampling structure of the survey is such that the data tend to be more representative of larger firms, overall the survey covers 85% of industrial output excluding the “*maquiladoras*”. The survey frequency is yearly and the variables collected cover various aspect of the firm’s operations: workers, wages, electricity usage, intermediate inputs usage²³, production, inventory, sales²⁴, investment in different types of physical assets, investment in R&D and in technology transfers.²⁵

²⁰We will focus on one specific dimension of firm heterogeneity, namely productivity.

²¹This work was carried out while I was in Aguascalientes and in compliance with Mexican Laws protecting the confidentiality of the data.

²²It is important to note that entry is not systematically captured by INEGI as the sample is refreshed only once every ten years. However a specific department of INEGI tends to follow up on newspapers and other sources of information the entry of new plants, in this way the most important new firms tend to be included even if this is not systematic.

²³The intermediate inputs used are split into imported and domestic inputs.

²⁴As for intermediate inputs also the sales are split into domestic and foreign sales.

²⁵For more details on the data see appendix A or refer to Iacovone (2008).

4.2 The Asymmetric Impact of Liberalization

In this section we will address two questions aiming at testing the predictions of our model. What is the average impact of increased import competition on productivity growth? And is this impact the same for all firms? The implicit assumption we make here is that productivity growth is an adequate proxy of innovative efforts.

It is a well documented feature of various firm-level studies that firms are heterogeneous in terms of their productivity (Tybout 2000). At the same time various firm-level studies have shown that trade liberalisation tends to influence positively the productivity of domestic firms (Pavcnik 2002, Roberts and Tybout 1996). However, based on the theoretical model developed in section 3.2, we would also expect the impact of increased foreign competition to be different across firms with different productivity levels.

In order to test this hypothesis, we first calculate the domestic production frontier defining it as the average value added labour productivity²⁶ of the top five firms in each sector²⁷, and for every firm we measure the distance from its domestic frontier as in equation 16. More specifically, for firm i belonging to sector j this is equal to the ratio between the productive frontier π_{jt}^F and its own labour productivity π_{it} . The wider the gap between the productivity of a firm and that of the “*top firms*” in its sector, the larger this distance index is.²⁸

$$DLF_{ijt} = \frac{\pi_{jt}^F}{\pi_{ijt}} \quad (16)$$

To answer the questions just outlined at the beginning of this section we estimate equation 17. Our explanatory variable is the growth of value added labour productivity of firm i between t and $t + 1$, and our main explanatory variables are the distance from the frontier (DLF_{ijt}), the tariffs faced by its foreign competitors in sector j and their interaction. We also add a number of plant level covariates, as well as year dummies to absorb the effect of macroeconomic shocks. We control for size, measured by employment, capital intensity, measured by the ratio of capital stock to number of workers, and average wages as a proxy for the quality of human capital. Finally, we also control for the plant expenditures in R&D and technological transfers. All variables, except tariffs, are in logarithm²⁹ and we estimate the model using both OLS and FE estimators. Because we have a lagged dependent

²⁶The value added labour productivity is calculated as the ratio between deflated value added and number of workers.

²⁷Sector is defined at four digits, based on the Mexican Classification of Manufacturing Activities (CMAP94) and each sector has in average between 98 and 132 plants, depending on the years, with the largest one having 470 plants and the smallest 11.

²⁸We follow in this calculation Griffith, Redding, and Simpson (2003).

²⁹When performing the log transformation we add 1 to the value of the original variables to avoid that zero values are transformed into missing values.

variable in this equation appearing on the denominator of the distance index our estimates will be biased (Cameron and Trivedi 2005, p.764). In particular the OLS coefficient will be downward biased while the FE coefficients will be upward bias (Arellano 2003).³⁰

$$\Delta\pi_{ijt} = \beta_0 + \beta_1 DLF_{ijt-1} + \beta_2 T_{jt-1} + \beta_3 T_{jt-1} \times DLF_{ijt-1} + \beta_4 X_{ijt-1} + \beta_5 Year + \mu_{it} \quad (17)$$

Based on our model we expect β_2 to be negative as lower tariffs should promote higher productivity growth spurred by the increased competitive pressure. We also expect β_3 to be positive, because, as discussed in section 3.2 the impact of increased liberalisation is less positive for firms that are more distant from the technological frontier. Finally, consistently with previous studies we expect β_1 to be positive as firms lagging behind tend to catch up with their respective frontier (Alvarez and Crespi 2007).

The main results are presented in table 7. In addition to the variables previously discussed, in the OLS specification we also include industry, state and year fixed effects. We first present a set of regressions where only include our main variables of interest and the fixed effects, models (1) and (2), and then include also the plant-level controls, models (3) and (4). Consistently with our expectations on the bias induced by the lagged dependent variable, the coefficient on the variable measuring the distance from frontier, which contains a lagged dependent variable in its denominator, appears to be larger in the FE than in the OLS. However it is important to underline that the qualitative results do not change between the two models. In fact, no matter which estimate we choose, in both models these variables are positive and significant.

Table 7 here

Our main finding is that the productivity of firms facing lower tariffs tends to grow faster but this productivity effect is lower for firms with larger distance from the productive frontier as the coefficient on the interaction is positive. The coefficients of the remaining variables are consistent with what we would have expected a-priori. In particular, we find evidence of catching up as distance from frontier positively affects subsequent productivity growth. It is also interesting to notice that the productivity of larger and more capital intensive firms tends to grow faster. Also, as expected, the productivity of firms paying higher wages grows faster. And finally, higher expenditures in R&D and technology transfers promote faster productivity growth. However, these control variables are likely to be endogenous; therefore, we do not want to push too much on their interpretation. In fact the principal purpose of introducing them is to control for firms' characteristics that may be correlated with the productivity growth and therefore, if omitted, could bias our principal coefficients of interest.

³⁰A possible extension to try to address this issue is to use a GMM estimator which makes use of the longitudinal dimension of the data to build appropriate instruments using the lagged variables. However in our case the reduced size of the longitudinal dimension makes the use of GMM less attractive, therefore we did not pursue this strategy.

For this reason in columns (1) and (2) of table 7 we exclude these regressors in order to confirm that their inclusion is not crucial for our results.

Because of the presence of the interaction we can calculate the impact of a percentage change in tariffs on productivity growth for different types of firms depending on their distance from the productive frontier.³¹ In figure 4.2 we graph these marginal effects based on the results from column (3) and (4) of table 7. The bottom line is that for most of the plants, except those in the top decile, e.g. the ones that are more distant from the production frontier, the tariffs reduction spurs their productivity growth.

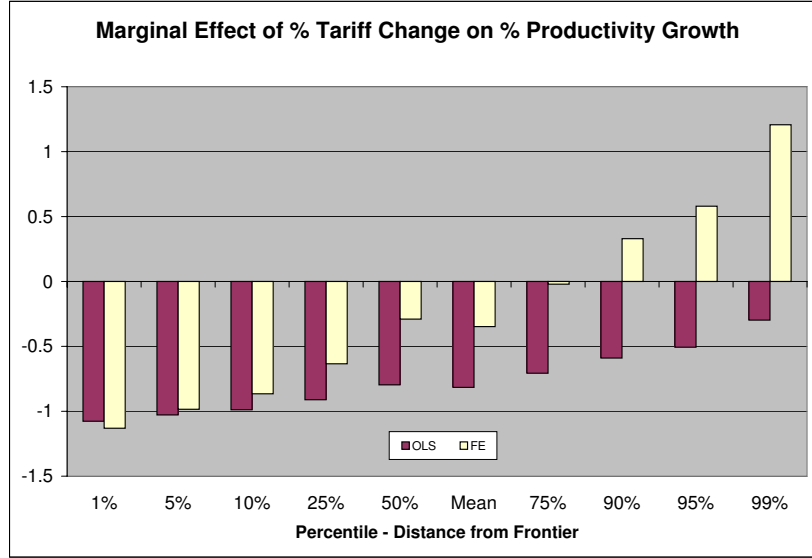


Figure 5: Marginal effect of Tariffs on Productivity Growth

The results from table 7 just discussed confirm the two basic predictions of the model. After having presented our main results, we will now discuss a set of potential concerns that may invalidate our findings and assess if these are truly robust.

First of all, an important issue to be discussed is the possibility that tariffs could be endogenous. Fundamentally we think this is not a major problem for two reasons. The main reason is that while it is reasonable to expect that an entire industry is likely to be able to influence its tariffs schedule, it is harder for a plant alone to influence the tariffs set for its entire industry. Therefore, if our analysis

³¹Our β of interest is equal to $\beta_2 + \beta_3 * \widehat{LogDistance}$.

was done using industry-level data we would be concerned about tariffs endogeneity while we think this is not a major issue in our study as we focus on plant-level data.

Moreover, if we analyze the way NAFTA negotiations were carried out we can strengthen our confidence about the Mexican tariffs phase out being exogenous. First, the NAFTA agreement faced Mexico with bilateral negotiations with partners that had more influence and negotiating power. Additionally, the negotiations were carried out in a relatively short period of time which reduces the possibility of external interventions and interferences from individual firms. Moreover, the high degree of uncertainty that surrounded the US Congress approval of NAFTA suggests that Mexican negotiators focused their minds on supporting the negotiating process to increase the chances of NAFTA being approved, rather than trying to defend the interests of individual firms.³² Indeed, these anecdotal remarks are consistent with the findings of Kowalczyk and Davis (1996) who argue that while for US tariffs there is evidence that higher duties and sectors with lower intra-industry trade were characterized by slower phase out, there is not such evidence when we analyze the phase out of Mexican tariffs except that these appear correlated with US phase-out.³³

Finally, to dispel some remaining doubts we analyze the evolution of Mexican tariffs under NAFTA and observe that, even at a rather disaggregated level (i.e. 6 digits), the rankings of the different tariffs are rather stable. This is shown by table 3 in appendix A where we split the tariffs in deciles and calculate the transition probabilities during the period under analysis. A similar conclusion is reached if we observe table 4 where we calculate the Spearman rank correlation between tariffs. The conclusion from this table is that, no matter which pair of years we consider, we can always reject the null hypothesis that the two tariff schedules are independent. This suggests that whatever the political economy was behind the tariffs structure this did not change much during the NAFTA period, therefore using 6-digits industry fixed effects we control for these time-invariant industry characteristics affecting the political economy of tariffs liberalization.³⁴

In appendix B.2 we also present a set of additional regressions (see tables 8 and 9) in order to check the robustness of our results.

First of all we exclude from our analysis the “top plants” used to calculate the productive frontier.

³²NAFTA was only approved by the US Congress only on December 8th,1993, by a narrow majority of 234-200 vote and it took effect after less than one month on January 1st, 1994.

³³Kowalczyk and Davis (1996) argue that empirical analysis at five-digit SITC level “suggests that from the perspective of Mexican negotiations, many other issues, including the overriding one of obtaining free trade in the near future with its Northern neighbours, were given higher priority than the questions of how to phase duties out”

³⁴A similar argument and solution is proposed by Schor (2004) and Goldberg and Pavcnik (2005).

Because these plants have been used to calculate the productive frontier we can expect that there will be some correlation, by construction, between the productive frontier and their productivity which could bias our results. The results are reported in columns (5) to (8) of table 8 in appendix B.2 and confirm that the exclusion of these plants does not influence our conclusions.

Secondly, because our dataset is an unbalanced panel and include plants that at some point are closed down and exit from the sample we are concerned that exiting could influence our results. In order to address this problem we first of all introduce a dummy variables that is equal to one when a firm will be exiting in the year and zero otherwise. The results are reported in columns (9) and (10) of table 8 and we notice that indeed the performance of exiting firms is, in the year before exiting, clearly worse than that of other firms. However the main coefficients of interest, i.e. the coefficient on tariffs and on the interaction between tariffs and distance from productive frontier, are substantially unchanged. We also repeat our estimations using a balanced panel and excluding altogether exiting plants from the sample, the results are reported in columns (11) and (12) of table 8. In this case, even if the main coefficients of interest are still significant and have the expected signs we observe that, differently from previous results, the coefficient on the interaction between tariffs and distance from frontier is larger in the OLS than in the FE model, we think this is probably a consequence of the selection bias generated when using a balanced panel and excluding all exiting plants.

In all our discussion we have assumed that increased competition and entry threat, captured by a reduction in Mexican tariffs under NAFTA, are having an uneven effect on firms with different productivity level. However, it is also possible that Mexican tariffs maybe capturing some other effect. For example, if Mexican tariffs and US tariffs under NAFTA are correlated³⁵ the reduction in Mexican tariffs may be identifying the impact of enhanced market access under NAFTA as we have not included US tariffs in our baseline regressions. To address this problem we include US tariffs and their interaction with distance from frontier. The results are reported in table 9 in appendix B.2, where in columns (13) and (14) we exclude the plant-level controls while in columns (15) and (16) we also include them³⁶. For simplicity we will concentrate on the results reported in columns (15) and (16) as these are substantially similar to the ones where we exclude the plant-level controls. The principal conclusion is that the inclusion of US tariffs does not change our previous results, the coefficients on Mexican tariffs and their interaction with distance from frontier are substantially identical. Further, it is interesting to notice that the increased access to US markets has a similar positive effect on productivity as the increase of domestic competition, in fact the size of the coefficients on US tariffs is very close to that on Mexican tariffs. Additionally, it is intriguing to notice that, in line with the predictions of recent trade models with heterogenous firms (Melitz 2003), also the expanded market

³⁵I thank Eric Verhoogen for this remark.

³⁶Notice that in these regressions we also include a dummy to control for exiting firms

access affects asymmetrically domestic firms with more productive firms benefitting more.

As a further robustness check we test if our results are influenced by the 1994 peso devaluation. It is fair to argue that, simultaneously to the NAFTA reforms, Mexican firms were also affected by the devaluation shock which could also influence different plants asymmetrically. In order to control for this we introduce the interaction between real exchange rate and the distance from frontier as additional control. The results are presented in Table 10 and show that the original impact of tariffs is somewhat attenuated and while in the OLS estimation the interaction between tariffs and distance from frontier is still positive and significant, in the case of the fixed-effect estimation this remains positive but becomes but marginally insignificant. At the same time, in the fixed-effect estimation the sign of the interaction between exchange rate and distance from frontier is negative supporting the idea that backward may have been negatively affected by the devaluation, probably because these were less able to reap the benefits of enhanced competitiveness on the export market. Extending these results, we restrict our sample to those products where quality differences are particularly important as it is the case of those products that Rauch defines as “differentiated” (Rauch 1999). The reason is that while for “homogenous products” we expect that what matters are mostly cost-cutting innovation, and the scope for innovation is therefore more limited, differently for “differentiated” products we expect that the “potential quality differences” between products give to producers more room to introduce not only cost-cutting process innovation but also product innovation. The results presented in Table 11 confirm our intuition and show that the impact of liberalization on productivity growth is actually larger and, besides controlling for the interaction of exchange rate with distance from frontier, the interaction between tariffs and distance from frontier is actually positive in all of our specifications.

To confirm these results pointing towards the importance of the “technology channel”, we split our sample based on the average sectoral R&D intensity in the pre-NAFTA period and we re-estimate our model just focusing on those sectors with that have an R&D intensity above the economy-wide median (in other words we focus on the top half most R&D intensive sectors). The results are reported in Table 11 and even more confirm that our main results are stronger for those sectors where the importance of innovative effort is particularly important which is what our model would also suggest. In a nutshell, the patterns observed previously that liberalization spurs innovative efforts especially in firms that are more advanced appear to be reinforced if we focus only on those sectors where the scope for innovative activity is larger, both in terms of product and process innovation.

Finally, in order to dispel the possibility that a key driver in our results is access to finance. We include a triple interaction in order to analyze if our results are stronger in those sectors characterized by more pronounced dependence on external finance. We add to our main interaction between distance

from frontier and tariffs also the Rajan-Zingales index³⁷ measuring the dependence from external finance (Rajan and Zingales 1998). The results are reported in Table 13 and confirm that our main results appear not to be driven by financial constraints as the coefficient of the triple interaction is not statistically different from zero.

5 Conclusions

In this paper we have shown that it is important, when analyzing the impact of exogenous policy shocks, to take into account micro-level heterogeneity. We started from a stylized fact showing an increase in the industrial inequality after NAFTA was implemented, despite a substantial exit of less productive plants. In order to rationalize such result we developed a neo-Schumpeterian growth model predicting that the impact of liberalization is asymmetric across different types of firms, with “good firms” benefitting more from the increase in competitive pressures than “bad ones”. In this model, the liberalization tends to generate two competing effects: on one side it spurs more innovative efforts, because of the increased entry threat by foreign competitors. On the other side, enhanced competition curtails expected profits and reduces the resources available to finance innovative activities. The “pro-competitive effect” is weaker for less advanced firms as for them it is harder to catch-up with the “technology frontier”.

We tested the predictions from our theoretical model and confirm that indeed liberalization affected asymmetrical different types of firms. In particular, a 10 percent reduction in tariffs spurred average productivity growth between 4 and 8 percent. However, while for backward firms this effect is much weaker if not close to zero, otherwise for more advanced ones this effect is stronger with productivity growing between 11 and 13 percent. Furthermore we showed that, as a confirmation of the technology-channel, these results appear to be stronger in those sectors where the scope for the innovative activities is more pronounced.

These findings have various implications. In the context of the empirical debate on the relationship between trade liberalization and growth they suggest that we should not be surprised by evidence that the effects of liberalization vary across countries because this could just be the consequence that the distribution of productivity across countries before the reforms differ. Furthermore, for policy makers being aware of the possible heterogeneous effects of the reforms is potentially even more important than knowing about the average impact of the reforms in order to devise appropriate

³⁷This index is a proxy to characterize the degree of dependence from external funds of a specific sector (at 4 digits) and it is equal to the average ratio of capital expenditures not financed with internal funds over total capital expenditures during the 1980-1990.

complementary policies and anticipate the political economy of the responses to the proposed reforms. Finally, these findings open the avenue to further research toward better understand why identical policies may have an asymmetric impact on heterogeneous firms. In particular, we would like to explore the mechanisms behind these heterogeneous reactions to liberalization. Are these determined by innovative efforts, product innovation, reorganization of the productive processes and training of the workforce? Answering these questions is particularly important for policy makers because it may suggest that while increasing competition may be good in spurring average productivity, it is also true that this effect may not hold for all type of firms. Therefore some complementary policies may be needed to support weaker firms to upgrade their capacities and keep up with the enhanced competitive environment. Clarifying these questions would help us to identify which type of policies would be more appropriate.

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A Appendix: Data

The Encuesta Industrial Anual (EIA) is an annual industrial survey that covers the Mexican manufacturing sector, with the exception of “maquiladoras.” The EIA was originally started in 1963 and then expanded in subsequent years, with the last expansion taking place in 1994 after the 1993 census. The post-1993 EIA includes 6,867 plants spread across 205 classes of activity representing the most important sector of manufacturing activities in Mexico based on the 1993 industrial census. In our analysis, we use the information for the 1993-2002 period and after cleaning the number of plants is reported in table 1

Table 1: Number of plants and exporters

| Year | No of plants | |
|------|--------------|-----------|
| | All | Exporting |
| 1994 | 6299 | 1586 |
| 1995 | 6070 | 1880 |
| 1996 | 5786 | 2061 |
| 1997 | 5572 | 2161 |
| 1998 | 5400 | 2106 |
| 1999 | 5255 | 1967 |
| 2000 | 5118 | 1914 |
| 2001 | 4952 | 1780 |
| 2002 | 4782 | 1696 |
| 2003 | 4626 | 1691 |

The sampling scheme is deterministic and based on the 1993 industrial census. For each one of the 205 selected “clase” the largest plants are selected up to the point when at least 85% of industrial output has been covered. In those cases where the average size of plants is very small (e.g. “fragmented classes”) up to a maximum of 120 plants are included and the coverage may fall to about 60-70% of the total industrial output in that specific “clase”. At the same time, for those cases where the “clase” is highly concentrated (i.e. less than 20 plants) all plants are included with a coverage of 100%.

The unit of observation is a plant described as “*the manufacturing establishment where the production takes place*”. Each plant is classified in its respective class of activity based on the basis of its principal product. The class of activity is equivalent to the 6-digit level CMAP (Mexican System of Classification for Productive Activities) classification.

In the EIA plants can be tracked through time thanks to a specific plant identifier.

A.1 Data Cleaning and Deflation

The original data have been deflated using appropriate deflators provided by Banco de Mexico. The values of domestic sales was deflated using the domestic price producer index and the value of exports sales was deflated using the export price index. We also deflated separately the intermediate inputs using for the domestic inputs the price index published by Banco de Mexico³⁸ while for the imported inputs we used the index of exported intermediate inputs and raw materials published by the Bureau of Labor Statistics³⁹. We also separately deflated the wage bill using the domestic consumer price index. Finally we deflated the value of investment in fixed assets by using four different deflators for each one of the different types of assets kindly provided by Banco de Mexico (i.e. machineries, office equipment, transport equipment, buildings and land).

In order to clean the data and correct for eventual inputting mistakes and outliers we trimmed the data and eliminated the largest and smallest 1% of the observations.

Also, because the EIA only provides information on capital stock at book value, we use the information from the Industrial Census of 1993 to obtain the exact value of capital stock at its replacement value as the initial capital stock.

We complement the data obtained from the industrial survey with information on Mexican tariffs obtained by Secretaría de Economía⁴⁰ and on US tariffs obtained by Romalis⁴¹.

³⁸www.banxico.gov.mx

³⁹www.bls.gov

⁴⁰www.economia.gob.mx

⁴¹<http://faculty.chicagogsb.edu/john.romalis/research/TariffL.ZIP>

Table 2: Variables description

| Variable Name | Description |
|--------------------------|---|
| Domestic Frontier Growth | Growth of the average labour productivity of top five firms in the sector |
| Distance from Frontier | Ratio of domestic frontier to plant specific labour productivity |
| Employment | Total number of workers (white collars and blue collars) |
| Average Wages | Total wage bill divided by number of employees |
| R&D | Expenses in in-house research and development |
| Technology transfers | Expenses to acquire technology (patents, engineering services, consultancy, etc.) |
| Exiting Plant | Dummy equal to 1 if the plant will exit the sample in the following year and zero otherwise |
| Capital Intensity | Ratio of capital stock divided by the total number of workers |
| US Tariffs | US Tariffs applied to Mexican products agreed under NAFTA |
| MX NAFTA Tariff | Mexican tariffs applied to US and Canadian products agreed under NAFTA |

Table 3: Tariffs Stability - Transition Matrix

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Total |
|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 1 | 80.82 | 9.59 | 4.57 | 1.83 | 1.37 | 0.91 | 0 | 0.46 | 0 | 0.46 | 100 |
| 2 | 11.92 | 63.58 | 17.88 | 1.99 | 1.99 | 0.66 | 1.99 | 0 | 0 | 0 | 100 |
| 3 | 5.52 | 7.73 | 58.56 | 20.99 | 2.21 | 1.66 | 2.76 | 0.55 | 0 | 0 | 100 |
| 4 | 4.95 | 1.65 | 12.64 | 49.45 | 27.47 | 1.1 | 2.2 | 0.55 | 0 | 0 | 100 |
| 5 | 2.19 | 3.28 | 3.83 | 16.39 | 51.37 | 16.39 | 3.28 | 2.73 | 0 | 0.55 | 100 |
| 6 | 2.86 | 2.86 | 1.71 | 4.57 | 10.86 | 55.43 | 16.57 | 3.43 | 1.14 | 0.57 | 100 |
| 7 | 0 | 1.58 | 0 | 0.53 | 2.63 | 12.11 | 60 | 18.95 | 4.21 | 0 | 100 |
| 8 | 0 | 0 | 2.86 | 1.71 | 0.57 | 6.86 | 14.29 | 57.14 | 13.71 | 2.86 | 100 |
| 9 | 0 | 1.08 | 0.54 | 0.54 | 2.16 | 2.7 | 3.24 | 14.05 | 66.49 | 9.19 | 100 |
| 10 | 0 | 0 | 0 | 0 | 0 | 0.57 | 0.57 | 0 | 12.07 | 86.78 | 100 |
| Total | 12.29 | 8.26 | 10.03 | 9.81 | 10.08 | 9.7 | 10.63 | 9.7 | 9.81 | 9.7 | 100 |

Table 4: Tariffs Stability - Spearman Rank Correlation

| | MXTariff93 | MXTariff94 | MXTariff95 | MXTariff96 | MXTariff97 | MXTariff98 | MXTariff99 | MXTariff2000 | MXTariff2001 |
|--------------|------------|------------|------------|------------|------------|------------|------------|--------------|--------------|
| MXTariff1993 | 1 | | | | | | | | |
| MXTariff1994 | 0.7182 | 1 | | | | | | | |
| MXTariff1995 | 0.711 | 0.9943 | 1 | | | | | | |
| MXTariff1996 | 0.6886 | 0.9693 | 0.9877 | 1 | | | | | |
| MXTariff1997 | 0.6488 | 0.9203 | 0.9522 | 0.9854 | 1 | | | | |
| MXTariff1998 | 0.5677 | 0.8096 | 0.8576 | 0.9173 | 0.9683 | 1 | | | |
| MXTariff1999 | 0.4466 | 0.6675 | 0.722 | 0.7961 | 0.8705 | 0.9382 | 1 | | |
| MXTariff2000 | 0.4451 | 0.6663 | 0.7212 | 0.7958 | 0.8706 | 0.937 | 0.9995 | 1 | |
| MXTariff2001 | 0.3129 | 0.4865 | 0.5244 | 0.5792 | 0.6344 | 0.6919 | 0.747 | 0.7447 | 1 |
| MXTariff2002 | 0.3118 | 0.4806 | 0.5174 | 0.5708 | 0.6256 | 0.681 | 0.7362 | 0.7344 | 0.9975 |

Table 5: Log of the distance from productive frontier - summary statistics

| Percentile | Log Distance from Frontier |
|------------|----------------------------|
| 1% | 0.61544 |
| 5% | 0.8588973 |
| 10% | 1.057851 |
| 25% | 1.443366 |
| Median | 1.920843 |
| Mean | 2.01634 |
| 75% | 2.465592 |
| 90% | 3.049695 |
| 95% | 3.466393 |
| 99% | 4.51252 |

Table 6: Market Share - summary statistics

| Percentile | Market Shares |
|------------|---------------|
| 1% | 0 |
| 5% | 0.0000174 |
| 10% | 0.0011921 |
| 25% | 0.004464 |
| Median | 0.0129202 |
| Mean | 0.0387934 |
| 75% | 0.0368139 |
| 90% | 0.0952364 |
| 95% | 0.1656317 |
| 99% | 0.3899864 |

B Appendix: Regressions

B.1 Main Results

Table 7: Asymmetric effect of liberalisation

| | OLS | FE | OLS | FE |
|---------------------------------|----------------------|----------------------|----------------------|----------------------|
| | (1) | (2) | (3) | (4) |
| Domestic Frontier Growth | 0.240*** (0.015) | 0.392*** (0.014) | 0.260*** (0.015) | 0.391*** (0.014) |
| MX Tariffs NAFTA (lagged) | -0.013*** (0.002) | -0.017*** (0.002) | -0.012*** (0.002) | -0.015*** (0.002) |
| Distance from Frontier (lagged) | 0.112*** (0.007) | 0.500*** (0.011) | 0.173*** (0.008) | 0.499*** (0.011) |
| Distance x Tariffs (lagged) | 0.003*** (0.001) | 0.006*** (0.001) | 0.002*** (0.001) | 0.006*** (0.001) |
| Employment (lagged) | | | 0.045*** (0.003) | 0.086*** (0.013) |
| Capital Intensity (lagged) | | | 0.021*** (0.002) | 0.004 (0.003) |
| Average Wages (lagged) | | | 0.083*** (0.009) | -0.026 (0.016) |
| R&D (lagged) | | | 0.004*** (0.001) | 0.006*** (0.002) |
| Technology Transfers (lagged) | | | 0.006*** (0.001) | 0.004*** (0.002) |
| Industry FE (6 digits) | Yes | No | Yes | No |
| Location FE | Yes | No | Yes | No |
| Year FE | Yes | Yes | Yes | Yes |
| Plant FE | No | Yes | No | Yes |
| Plant-level controls | No | No | Yes | Yes |
| N | 44948 | 44948 | 44176 | 44176 |
| r2 | 0.056 | 0.214 | 0.075 | 0.217 |

B.2 Robustness Checks

Table 8: Robustness checks of asymmetric effect of liberalisation: exclude “top plants”

| | Exclude top plants | | | | Exclude top plants + control for exiting | | | |
|---------------------------------|----------------------|----------------------|----------------------|----------------------|--|----------------------|----------------------|----------------------|
| | OLS | FE | OLS | FE | OLS | FE | OLS | FE |
| | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) |
| Domestic Frontier Growth | 0.232*** (0.016) | 0.379*** (0.014) | 0.251*** (0.016) | 0.378*** (0.014) | 0.254*** (0.016) | 0.380*** (0.014) | 0.268*** (0.014) | 0.379*** (0.013) |
| MX Tariffs NAFTA (lagged) | -0.014*** (0.002) | -0.018*** (0.002) | -0.013*** (0.002) | -0.016*** (0.002) | -0.013*** (0.002) | -0.015*** (0.002) | -0.017*** (0.002) | -0.014*** (0.002) |
| Distance from Frontier (lagged) | 0.132*** (0.007) | 0.507*** (0.012) | 0.193*** (0.008) | 0.507*** (0.012) | 0.201*** (0.008) | 0.519*** (0.012) | 0.217*** (0.008) | 0.521*** (0.012) |
| Distance x Tariffs (lagged) | 0.004*** (0.001) | 0.007*** (0.001) | 0.003*** (0.001) | 0.006*** (0.001) | 0.003*** (0.001) | 0.005*** (0.001) | 0.005*** (0.001) | 0.004*** (0.001) |
| Employment (lagged) | | | 0.052*** (0.003) | 0.100*** (0.013) | 0.046*** (0.003) | 0.076*** (0.013) | 0.037*** (0.003) | 0.030** (0.012) |
| Capital Intensity (lagged) | | | 0.021*** (0.002) | 0.003 (0.003) | 0.018*** (0.002) | 0.001 (0.003) | 0.012*** (0.002) | 0.002 (0.003) |
| Average Wages (lagged) | | | 0.079*** (0.009) | -0.024 (0.017) | 0.083*** (0.009) | -0.033** (0.016) | 0.079*** (0.008) | -0.077*** (0.015) |
| R&D (lagged) | | | 0.005*** (0.001) | 0.007*** (0.002) | 0.004*** (0.001) | 0.006*** (0.002) | 0.004*** (0.001) | 0.005*** (0.002) |
| Technology Transfers (lagged) | | | 0.006*** (0.001) | 0.004** (0.002) | 0.006*** (0.001) | 0.004** (0.002) | 0.007*** (0.001) | 0.004*** (0.002) |
| Exiting Plant | | | | | -0.662*** (0.039) | -0.661*** (0.038) | | |
| Balanced panel | No | No | No | No | No | No | Yes | Yes |
| Industry FE (6 digits) | Yes | No | Yes | No | Yes | No | Yes | No |
| Location FE | Yes | No | Yes | No | Yes | No | Yes | No |
| Year FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Plant FE | No | Yes | No | Yes | No | Yes | No | Yes |
| Plant-level controls | No | No | Yes | Yes | Yes | Yes | Yes | Yes |
| N | 42872 | 42872 | 42125 | 42125 | 42125 | 42125 | 36358 | 36358 |
| r2 | 0.069 | 0.220 | 0.089 | 0.224 | 0.113 | 0.245 | 0.134 | 0.252 |

Table 9: Robustness checks of asymmetric effect of liberalisation: controlling for US tariffs

| | OLS (13) | FE (14) | OLS (15) | FE (16) |
|---------------------------------|----------------------|----------------------|----------------------|----------------------|
| Domestic Frontier Growth | 0.243*** (0.016) | 0.387*** (0.014) | 0.262*** (0.016) | 0.386*** (0.014) |
| MX Tariffs NAFTA (lagged) | -0.013*** (0.002) | -0.015*** (0.003) | -0.012*** (0.002) | -0.014*** (0.003) |
| US Nafta Tariff (lagged) | -0.007* (0.004) | -0.015*** (0.005) | -0.005 (0.004) | -0.013*** (0.005) |
| Distance from Frontier (lagged) | 0.141*** (0.007) | 0.516*** (0.012) | 0.200*** (0.008) | 0.515*** (0.012) |
| Distance x MX Tariffs (lagged) | 0.003*** (0.001) | 0.005*** (0.001) | 0.003*** (0.001) | 0.004*** (0.001) |
| Distance x US Tariffs (lagged) | 0.003 (0.002) | 0.005** (0.002) | 0.002 (0.002) | 0.004* (0.003) |
| Exiting Plant | -0.714*** (0.040) | -0.692*** (0.038) | -0.677*** (0.040) | -0.671*** (0.039) |
| Employment (lagged) | | | 0.046*** (0.003) | 0.080*** (0.013) |
| Capital Intensity (lagged) | | | 0.018*** (0.002) | 0.001 (0.003) |
| Average Wages (lagged) | | | 0.085*** (0.009) | -0.034** (0.017) |
| R&D (lagged) | | | 0.004** (0.001) | 0.006*** (0.002) |
| Technology Transfers (lagged) | | | 0.006*** (0.001) | 0.004*** (0.002) |
| Industry FE (6 digits) | Yes | No | Yes | No |
| Location FE | Yes | No | Yes | No |
| Year FE | Yes | Yes | Yes | Yes |
| Plant FE | No | Yes | No | Yes |
| Plant-level controls | No | No | Yes | Yes |
| N | 41480 | 41480 | 40760 | 40760 |
| r2 | 0.098 | 0.245 | 0.115 | 0.247 |

Table 10: Robustness checks of asymmetric effect of liberalisation: controlling also for exchange rate

| | OLS | FE | OLS | FE |
|-----------------------------------|----------------------|----------------------|----------------------|----------------------|
| | (17) | (18) | (19) | (20) |
| Domestic Frontier Growth | 0.243*** (0.016) | 0.389*** (0.014) | 0.262*** (0.016) | 0.387*** (0.014) |
| MX Tariffs NAFTA (lagged) | -0.012*** (0.002) | -0.009*** (0.003) | -0.011*** (0.002) | -0.009*** (0.003) |
| US Nafta Tariff (lagged) | -0.006 (0.004) | -0.008 (0.005) | -0.003 (0.004) | -0.007 (0.005) |
| Distance from Frontier (lagged) | 0.177*** (0.027) | 0.666*** (0.031) | 0.240*** (0.028) | 0.652*** (0.032) |
| Distance x Exchange Rate (lagged) | -0.000 (0.000) | -0.001*** (0.000) | -0.000 (0.000) | -0.001*** (0.000) |
| Distance x MX Tariffs (lagged) | 0.002** (0.001) | 0.002 (0.001) | 0.002* (0.001) | 0.002 (0.001) |
| Distance x US Tariffs (lagged) | 0.002 (0.002) | 0.002 (0.003) | 0.001 (0.002) | 0.001 (0.003) |
| Exiting Plant | -0.714*** (0.040) | -0.688*** (0.039) | -0.677*** (0.040) | -0.669*** (0.039) |
| Employment (lagged) | | | 0.046*** (0.003) | 0.074*** (0.013) |
| Capital Intensity (lagged) | | | 0.018*** (0.002) | 0.001 (0.003) |
| Average Wages (lagged) | | | 0.085*** (0.009) | -0.035** (0.017) |
| R&D (lagged) | | | 0.004** (0.001) | 0.006*** (0.002) |
| Technology Transfers (lagged) | | | 0.006*** (0.001) | 0.004*** (0.002) |
| Industry FE (6 digits) | Yes | No | Yes | No |
| Location FE | Yes | No | Yes | No |
| Year FE | Yes | Yes | Yes | Yes |
| Plant FE | No | Yes | No | Yes |
| Plant-level controls | No | No | Yes | Yes |
| N | 41480 | 41480 | 40760 | 40760 |
| r2 | 0.098 | 0.246 | 0.115 | 0.248 |

Table 11: Robustness checks of asymmetric effect of liberalisation: focus on differentiated products

| | OLS (21) | FE (22) | OLS (23) | FE (24) |
|-----------------------------------|----------------------|----------------------|----------------------|----------------------|
| Domestic Frontier Growth | 0.209*** (0.017) | 0.353*** (0.015) | 0.228*** (0.017) | 0.351*** (0.015) |
| MX Tariffs NAFTA (lagged) | -0.013*** (0.003) | -0.011*** (0.003) | -0.013*** (0.003) | -0.011*** (0.003) |
| US Nafta Tariff (lagged) | 0.003 (0.005) | 0.001 (0.006) | 0.006 (0.005) | 0.003 (0.006) |
| Distance from Frontier (lagged) | 0.181*** (0.031) | 0.657*** (0.033) | 0.245*** (0.031) | 0.636*** (0.034) |
| Distance x Exchange Rate (lagged) | -0.000 (0.000) | -0.001*** (0.000) | -0.000* (0.000) | -0.000*** (0.000) |
| Distance x MX Tariffs (lagged) | 0.003*** (0.001) | 0.003** (0.001) | 0.003*** (0.001) | 0.003* (0.002) |
| Distance x US Tariffs (lagged) | -0.001 (0.002) | -0.003 (0.003) | -0.002 (0.002) | -0.004 (0.003) |
| Exiting Plant | -0.715*** (0.041) | -0.689*** (0.040) | -0.675*** (0.041) | -0.661*** (0.040) |
| Employment (lagged) | | | 0.048*** (0.004) | 0.095*** (0.014) |
| Capital Intensity (lagged) | | | 0.018*** (0.002) | 0.000 (0.003) |
| Average Wages (lagged) | | | 0.085*** (0.010) | -0.021 (0.017) |
| R&D (lagged) | | | 0.004** (0.002) | 0.005*** (0.002) |
| Technology Transfers (lagged) | | | 0.006*** (0.001) | 0.005*** (0.002) |
| Industry FE (6 digits) | Yes | No | Yes | No |
| Location FE | Yes | No | Yes | No |
| Year FE | Yes | Yes | Yes | Yes |
| Plant FE | No | Yes | No | Yes |
| Plant-level controls | No | No | Yes | Yes |
| N | 36392 | 36392 | 35739 | 35739 |
| r2 | 0.099 | 0.246 | 0.116 | 0.248 |

Table 12: Robustness checks of asymmetric effect of liberalisation: focus on R&D intensive sectors

| | OLS (25) | FE (26) | OLS (27) | FE (28) |
|-----------------------------------|----------------------|----------------------|----------------------|----------------------|
| Domestic Frontier Growth | 0.214*** (0.026) | 0.375*** (0.024) | 0.245*** (0.026) | 0.375*** (0.024) |
| MX Tariffs NAFTA (lagged) | -0.026*** (0.007) | -0.036*** (0.007) | -0.026*** (0.007) | -0.032*** (0.007) |
| US Nafta Tariff (lagged) | 0.004 (0.008) | 0.005 (0.008) | 0.004 (0.007) | 0.006 (0.008) |
| Distance from Frontier (lagged) | -0.007 (0.068) | 0.499*** (0.070) | 0.074 (0.067) | 0.515*** (0.071) |
| Distance x Exchange Rate (lagged) | 0.000* (0.000) | 0.000 (0.000) | 0.000* (0.000) | -0.000 (0.000) |
| Distance x MX Tariffs (lagged) | 0.013*** (0.004) | 0.015*** (0.004) | 0.013*** (0.004) | 0.013*** (0.004) |
| Distance x US Tariffs (lagged) | -0.006 (0.005) | -0.010* (0.005) | -0.006 (0.005) | -0.011** (0.005) |
| Exiting Plant | -0.694*** (0.080) | -0.646*** (0.087) | -0.634*** (0.077) | -0.620*** (0.085) |
| Employment (lagged) | | | 0.054*** (0.006) | 0.058** (0.024) |
| Capital Intensity (lagged) | | | 0.023*** (0.004) | -0.004 (0.005) |
| Average Wages (lagged) | | | 0.102*** (0.016) | -0.038 (0.029) |
| R&D (lagged) | | | 0.006*** (0.002) | 0.008*** (0.002) |
| Technology Transfers (lagged) | | | 0.004*** (0.001) | 0.003 (0.003) |
| Industry FE (6 digits) | Yes | No | Yes | No |
| Location FE | Yes | No | Yes | No |
| Year FE | Yes | Yes | Yes | Yes |
| Plant FE | No | Yes | No | Yes |
| Plant-level controls | No | No | Yes | Yes |
| N | 14404 | 14404 | 14206 | 14206 |
| r2 | 0.090 | 0.257 | 0.117 | 0.257 |

Table 13: Robustness checks of asymmetric effect of liberalisation: exploring relevance of financial dependence

| | OLS | FE | OLS | FE |
|---------------------------------|----------------------|----------------------|----------------------|----------------------|
| Domestic Frontier Growth | 0.220*** (0.016) | 0.368*** (0.014) | 0.239*** (0.016) | 0.366*** (0.014) |
| MX Tariffs NAFTA (lagged) | -0.013*** (0.003) | -0.015*** (0.003) | -0.013*** (0.003) | -0.014*** (0.003) |
| US Nafta Tariff (lagged) | -0.004 (0.004) | -0.012** (0.005) | -0.003 (0.004) | -0.009* (0.005) |
| Distance from Frontier (lagged) | 0.138*** (0.010) | 0.523*** (0.016) | 0.189*** (0.010) | 0.522*** (0.016) |
| Distance x MX Tariffs (lagged) | 0.003** (0.001) | 0.005*** (0.001) | 0.002** (0.001) | 0.004*** (0.001) |
| Distance x US Tariffs (lagged) | 0.003 (0.002) | 0.004 (0.002) | 0.002 (0.002) | 0.003 (0.003) |
| MX Tariffs x RZ | -0.002 (0.006) | -0.003 (0.006) | 0.001 (0.006) | -0.001 (0.006) |
| Distance x RZ | -0.012 (0.025) | -0.047 (0.032) | 0.018 (0.024) | -0.043 (0.032) |
| MX Tariff x Dist x RZ | 0.002 (0.003) | 0.001 (0.003) | 0.002 (0.003) | 0.000 (0.003) |
| Exiting Plant | -0.709*** (0.039) | -0.687*** (0.038) | -0.671*** (0.040) | -0.665*** (0.039) |
| Employment (lagged) | | | 0.047*** (0.003) | 0.085*** (0.013) |
| Capital Intensity (lagged) | | | 0.018*** (0.002) | 0.001 (0.003) |
| Average Wages (lagged) | | | 0.083*** (0.009) | -0.034** (0.017) |
| R&D (lagged) | | | 0.004*** (0.001) | 0.006*** (0.002) |
| Technology Transfers (lagged) | | | 0.006*** (0.001) | 0.004** (0.002) |
| Industry FE | Yes | No | Yes | No |
| Location FE | Yes | No | Yes | No |
| Year FE | Yes | Yes | Yes | Yes |
| Plant FE | No | Yes | No | Yes |
| N | 40739 | 40739 | 40029 | 40029 |
| r2 | 0.096 | 0.241 | 0.113 | 0.244 |